

recite that the second polymer layer "is partially cured to a B-stage state". Support for this amendment to Claim 1 is found on Page 9 line 15 of the present specification.

Claims 1-20 were rejected under 35 U.S.C. §103(a) as allegedly obvious over U.S. Patent No. 6,228,678 to Gilleo, et al. ("Gilleo, et al.") in view of U.S. Patent No. 6,372,544 to Halderman, et al. ("Halderman, et al."). Applicants' respectfully traverse the §103 rejection and submit the following.

Applicants submit that the claims of the present application are not rendered obvious by the disclosures of the applied references because the applied references fail to teach or suggest all of the limitations of applicants' claimed method. Specifically, the applied references fail to teach or suggest, "*forming a second polymeric material that is partially cured to a B-stage state over said first polymeric material and said conductive bump material*", as recited in amended Claim 1. "To establish a *prima facie* case of obviousness of a claimed invention all the claimed limitations must be taught or suggested by the prior art". In re Wilson, 424 F.2d 1382, 1385, 165 USPQ 44, 496 (CCPA 1970).

Applicants submit that Claim 1 is not made obvious by the disclosure of Gilleo, et al., since the applied reference does not teach or suggest applicants' claimed method. Specifically, the primary reference Gilleo, et al. does not teach or suggest "*forming a second polymeric material that is partially cured to a B-stage state over said first polymeric material and said conductive bump material*". Applicants observe, referring to Page 5 of the Final Rejection, that the Examiner agrees that, "Gilleo fails to teach a partially cured second polymeric material over a first polymeric material and conductive bump material".

Additionally, Gilleo, et al. fail to teach or suggest partially curing the second polymeric material to a B-stage state. Curing a polymeric material to a B-stage state requires advancing the reaction of a thermosetting polymer to below the gel point to which the material becomes

insoluble. The gel point is the point at which cross-linking occurs. B-staging renders thermosetting materials non-tacky since it raises the glass transition temperature of the polymer to above room temperature. Tacky materials are soft at room temperature. In thermoplastics, this is not possible because thermoplastics do not react. Thermoplastics do not cross-link because all the reactions to the polymer backbone have concluded.

Gilleo, et al. do not teach or suggest partially curing the second polymeric layer to a B-stage state. Applicants observe that one embodiment of the Gilleo, et al. disclosure is a first polymeric layer which includes a thermoplastic resin as the main component and a B-stage thermoset as a lesser component. Although Gilleo, et al. discloses that B-stage thermosets may be present in the first polymeric layer there is no teaching or suggestion of a B-stage thermoset being utilized in the second polymeric layer. Referring to Column 8, line 43-65, the second polymeric layer disclosed in Gilleo, et al. comprises a flux system including epoxy resins. Gilleo, et al. does not teach or suggest partially curing the second polymeric layer to form a B-stage state as recited in amended Claim 1.

Additionally, Gilleo, et al. disclose the use of thermoplastic polymers as the main component of the underfill. Specifically, Gilleo, et al. referring to Column 7, lines 29-31, disclose that their method eliminates the problems associated with thermoset underfills by incorporating thermoplastics. Therefore, the Gilleo, et al. disclosure teaches away from the applicants' claimed invention because Gilleo, et al. favor thermoplastics that cannot be cured to a B-stage state.

Halderman, et al., do not alleviate the deficiency of Gilleo, et al. since Halderman, et al. do not teach or suggest applicants' claimed method. Specifically, Halderman, et al. do not teach or suggest forming a bilayer underfill, "comprising the steps of forming a first polymeric material on a surface of a semiconductor wafer having interconnect pads disposed thereon;

patterning said first polymeric to provide openings that expose said interconnect pads; forming conductive bump material in said openings; *forming a second polymeric material that is partially cured to a B-stage state over said first polymeric material and said conductive bump material*; dicing said semiconductor wafer into individual chips; and bonding at least one of said individual chips to an external substrate, wherein during such bonding said conductive bump material penetrates said second polymeric material and contacts a surface of said external substrate", as recited in amended Claim 1.

Applicants submit that the disclosure of Halderman, et al. is substantially removed from applicants' claimed method. Halderman, et al. disclose a method of reducing the incidence of cracking of the underfill material and solder balls by softening the underfill material. More specifically, Halderman, et al., referring to Column 2, lines 23-29, disclose, "a polymeric bonding underfill material disposed between the semiconductor die, and the polymeric bonding material further disposed along the edges of the semiconductor die forming a fillet of underfill material surrounding the edges of the semiconductor die, wherein the fillet is made substantially compliant so as to reduce occurrences of crackings in the underfill material."

Applicants submit that Halderman, et al. fail to teach or suggest a second polymeric layer that is partially cured to a B-stage state atop a first polymeric material and conductive bump material. Halderman, et al. only disclose a single layer of polymeric material. Therefore, Halderman, et al. fail to teach or suggest a second polymeric layer, let alone a second polymeric material that is partially cured to a B-stage state.

Additionally, Halderman, et al. do not teach or suggest partially curing a polymeric layer to a B-stage state. Halderman, et al. disclose curing the polymer material until thermosetting cross-links are formed and then applying "thermal energy to the cured polymeric material sufficiently to break cross-links in the cured polymeric material to thereby render the

fillet compliant". See Column 2, lines 49-51. Halderman, et al. disclose breaking the bonds of the cross-links after the material is fully cured.

As stated above, curing a polymer material to a B-stage state is advancing the reaction of thermosetting materials to below the gel point to which the material become insoluble. The gel point is the point at which cross-linking occurs. B-staging concludes before cross-links are formed in the structure of a thermoset polymer. Therefore, cross-linking is avoided when curing a thermosetting polymer to a B-stage state. Halderman, et al. disclose forming cross-links and later breaking the cross-links. Therefore, Halderman, et al. do not teach or suggest curing a polymer to a B-stage state as recited in amended Claim 1.

Halderman, et al. also fail to teach or suggest bonding of individual chips to an external substrate, wherein during such bonding the conductive bump material penetrates the second polymeric material and contacts a surface of said external substrate as recited in amended Claim 1. Halderman, et al. fail to teach or suggest every limitation of applicants' claimed method.

Applicants further submit that the Halderman, et al. teach away from applicants' claimed method. Halderman, et al. teach away from partially curing the second polymeric layer, as recited in amended Claim 1. Halderman, et al., referring to Column 3 lines 58-62, disclose that, "the treatment with an appropriate solvent chemically breaks the cross-linked molecules, generally referred to as the cross-links, and essentially uncures the polymeric underfill material". Hence, Halderman, et al. teach a hard, fully cured segment 42 and a soft, uncured segment 40. There is no teaching or suggestion of a partially cured segment in Halderman, et al.

The §103 rejection also fails because there is no motivation in the applied references which suggests modifying the methods disclosed therein to include applicants' claimed method

which includes forming a bilayer underfill layer by forming, "a first polymeric material on a surface of a semiconductor wafer having interconnect pads disposed thereon; patterning said first polymeric layer to provide openings that expose said interconnect pads; forming conductive bump material in said openings; *forming a second polymeric material that is partially cured to a B-stage state over said first polymeric material and said conductive bump material*; dicing said semiconductor wafer into individual chips; and bonding at least one of said individual chips to an external substrate, wherein during such bonding said conductive bump material penetrates said second polymeric material and contacts a surface of said external substrate".

In contrast, the applied references do not teach or suggest a partially cured second polymeric layer of the B-stage state formed atop the first polymeric layer. This rejection is thus improper since the prior art does not suggest this drastic modification. The law requires that a prior art reference provide some teaching, suggestion, or motivation to make the modification obvious.

Here, there is no motivation provided in the disclosures of the applied prior art references, or otherwise of record, which would lead one skilled in the art to modify the methods of the applied references to include applicants' claimed sequence of processing steps recited in amended Claim 1 that lead to the formation of microelectronic interconnect structure containing a bilayer underfill layer. "The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." In re Fritch, 972 F.2d, 1260, 1266, 23 USPQ 1780, 1783-84 (Fed. Cir. 1992).

Additionally, there is no motivation to combine Halderman, et al. and Gilleo, et al. because combining the references renders the prior art references unsatisfactory for their

intended purposes. It is the Examiner's position, referring to Page 5 of the Final Rejection, that "it would have been obvious for one of ordinary skill in the art of making semiconductor devices to incorporate Halderman's teaching into Gilleo's method to partially cure the second polymeric material in order to harden the polymeric material." The Examiner specifically notes Claim 10 of the Halderman, et al. reference where, "hardening comprises curing the polymeric material thereby forming cross-links".

Halderman, et al. incorporate cross-linking (thermosetting) polymers as underfill. See Column 3, lines 50-62. Thermosetting polymers cross-link and do not soften and flow when heated. In fact, thermosetting polymers become permanently hard when heat is applied to them due to cross-linking. Halderman, et al. are directed at softening a portion of the thermoset polymers by breaking the cross-links via chemical reaction or excessive thermal heating. Gilleo, et al. incorporate thermoplastic or very low cross-linked polymers in order to allow for reworking of the chip during the mounting step. See Column 7, lines 29-31. Thermoplastics are plastics that do not cross-link and soften and flow when heated. Gilleo, et al. eliminate the problems associated with thermoset underfills by incorporating, a thermoplastic resin as the main component of the underfill. See id.

One of ordinary skill in the art would not be motivated to combine the disclosure of Halderman, et al., concerning breaking cross-linked molecules in thermosets, with the disclosure of Gilleo, et al., disclosing thermoplastics that do not incorporate cross-linked molecules. The method of Halderman, et al. would not perform its' intended purpose when utilized with thermoplastic structures that do not include cross-linked molecules and therefore there is no motivation to combine Gilleo, et al. with Halderman, et al. to create the applicants' claimed method recited in amended Claim 1. If proposed modification would render the prior art invention being modified unsatisfactory for its' intended purpose, than there is no

suggestion or motivation to make the proposed modification. In re Gordon, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984).

Based on the above amendments and remarks, the §103 rejections have been obviated; therefore reconsideration and withdrawal of the instant rejections are respectfully requested.

In summary, applicants respectfully submit that this application is in condition for allowance. Accordingly, applicants respectfully request that this application be allowed and a Notice of Allowance be issued. If the Examiner believes that a telephone conference with the applicants' representatives would be advantageous to the disposition of this case, the applicants request that the Examiner telephone the undersigned.

Respectfully submitted,



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**MARKED-UP VERSION SHOWING CHANGES MADE****IN THE CLAIMS:**Please amend Claim 1 as follows:

1. (Twice amended) A method of forming a microelectronic interconnect structure containing a bilayer underfill layer comprising the steps of:
  - (a) forming a first polymeric material on a surface of a semiconductor wafer having interconnect pads disposed thereon;
  - (b) patterning said first polymeric material to provide openings that expose said interconnect pads;
  - (c) forming conductive bump material in said openings;
  - (d) forming a second polymeric material that is partially cured to a B-stage state over said first polymeric material and said conductive bump material;
  - (e) dicing said semiconductor wafer into individual chips; and
  - (f) bonding at least one of said individual chips to an external substrate, wherein during said bonding said conductive bump material penetrates said second polymeric material and contacts a surface of said external substrate.